

ABSTRACTS OF PAPERS

**Fifth Annual Albert L. Tester Memorial Symposium
10–11 April 1980¹**

The Albert L. Tester Memorial Symposium is held in honor of Professor Albert Tester who, at the time of his death in 1974, was Senior Professor of Zoology at the University of Hawaii. The faculty and students of the Department of Zoology proposed an annual symposium of student research papers as a means of honoring, in a continuing and active way, Dr. Tester's lively encouragement of student research in a broad range of fields within marine biology. Papers reporting original research on any aspect of biology are solicited from students at the University and these papers are presented at the symposium, which takes place during the spring semester. Income from contributions to the Albert L. Tester Memorial Fund of the University of Hawaii Foundation are used to provide two prizes for the best papers by graduate students in the Department of Zoology. Papers are judged on quality, originality, and importance of research reported, as well as the quality of the public presentation. Judges include several members of the faculty of the Department of Zoology as well as winners of the symposium from the preceding year, when possible. In addition, a distinguished scholar from another university is invited to participate in the symposium as a judge and to present the major symposium address. This year Dr. Gareth Nelson of the American Museum of Natural History, a former student of Dr. Tester, participated in the symposium.

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**Aspects of Abundance and Reproduction in Hawaiian Enoploteuthid and
Ommastrephid Squid**

LISA M. BOUCHER²

In a 17-month midwater trawl-sampling program approximately 20 km west of Oahu, Hawaii, three enoploteuthid species, *Pterygioteuthis microlampas*, *Pyroteuthis addolux*, and *Abraliopsis* sp. B, were the most commonly captured cephalopods. The biomass of the most numerically abundant of the enoploteuthid species, *Pterygioteuthis microlampas*, was estimated at less than 1 g

dry w/100 m² sea surface area, and that of the largest species, *Pyroteuthis addolux*, less than 4 g/1000 m². While these values may be biased due to net avoidance, it appears that the extent of enoploteuthid net avoidance is not as great as avoidance by ommastrephids, which are commonly seen at the surface at night, but are rarely captured in trawls.

Enoploteuthid larval abundance estimates were higher than those of the ommastrephids, probably due to differential net avoidance. Ommastrephid larvae larger than 2 mm

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in mantle length were rarely captured, while enoploteuthid larvae of all size categories were captured regularly, indicating that larval ommastrephids are capable of net avoidance. Seasonal trends in adult abundance were not evident. Within the families, some spawning occurs all year, though fall peaks occurred in both enoploteuthid and ommastrephid larval abundance. The

greatest abundance of ommastrephid larvae was during June 1978. Fecundity, egg size, and ovarian caloric values are comparable for three of the species examined. *Pterygioteuthis microlampas* differs in its reproductive pattern of relatively higher fecundity, smaller egg sizes, and seasonal cycle of reproduction.

Iodine as an Environmental Factor Modifying Thiourea Taste Sensitivity

BARBARA CHAPMAN³

This study explores the relationship between iodine availability and thiourea sensitivity in a goitrous human community in Java. The varying sensitivity to thiourea chemicals has been widely used as a genetic marker for human populations since its discovery in 1923. The percentage of any population insensitive to the taste of the thioureas is usually far less than 50 percent, ranging from only 1 to 8 percent in American Indians to 45 percent in Greenland Eskimos. Studies with families and mono- and dizygotic twins show the taste sensitivity to be inherited by a simple dominant-recessive gene with minor modifications from age, sex, and smoking. Yet, age, sex, and smoking habit differences do not explain all the variation in phenotypes within a population; thus, the search continues for environmental factors that modify thiourea taste sensitivity. Certain animal experiments suggest sensitivity to thiourea might be modifiable by availability of iodine.

In early 1977, 547 men, women, and children in an endemic goiter community in Central Java were tested for taste sensitivity using PROP (6-*n*-propyl-2-thiouracil) in a modified Harris-Kalmus sorting technique. Of the original group, 411 were retested in mid-1978 after a majority of the community had received iodized oil injections in February 1978.

At the time of the first test, 46 percent of the sample were insensitive to PROP, making them relatively insensitive by comparison to other human populations. The sample showed males slightly less sensitive than females and a slight decrease of sensitivity with age. Of the 411 retested after iodized oil shots, only 27 percent were insensitive. Most individuals increased their sensitivity by one level or more (49 percent), while 37 percent maintained their original sensitivity and 12 percent decreased in sensitivity. The increase in iodine made available to this population in oil injections appears to have increased overall population sensitivity to thiourea chemicals, suggesting iodine as an additional environmental modifier to the standard age, sex, and smoking habit modifiers of thiourea sensitivity.

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Ionic Mechanisms Underlying Light-Evoked Depolarizations in the Retina of *Strombus*, a Marine Gastropod⁴

KEVIN S. CHINN⁵

The retinal type 2 cells of *Strombus luhuanus* described by Quandt and Gillary (J. Exp. Biol. 1979, 80:287) show characteristic light-evoked depolarizations (LED). The responses to brief flashes of white light exhibited two peaks or phases (amplitudes about 15 mV). The latency to the first peak was generally about 0.2 sec, while that to the second was 0.5–1.0 sec. The ionic mechanisms underlying the LED were studied by examining the effects on intracellularly recorded potentials of perfusion media (modified ASW) having different ionic compositions or pharmacological agents. The experiments indicate: (1) The resting potential of these cells is governed primarily by $[K^+]_o$; the resting potential changed approximately $50 \text{ mV}/10 \times [K^+]_o$. (2) The LED was tetrodotoxin-insensitive, remaining unchanged at concentrations of up to $6 \times 10^{-6} \text{ M TTX}$. (3) Lowering $[Na^+]_o$ by replacement with choline or tetramethylammonium

ions decreased both phases of the response. This decrease, approximately a linear function of $\log [Na^+]_o$, was greater for the second phase than the first. (4) Total replacement of Na^+ with Li^+ markedly reduced phase 1 (in some cases to zero); this also reduced phase 2, but less than phase 1. (5) Lowering pH from 7.7 (normal) to 5.5 reversibly abolished phase 2, while phase 1 was only reduced after an initial increase. (6) The results of application of 4-aminopyridine and tetraethylammonium chloride suggest the occurrence during the LED of a K^+ current. The onset of this current occurs sometime during phase 1 and lasts throughout phase 2. (7) Input resistance decreased in two phases, corresponding to the respective phases of the LED. (8) Changing $[Ca^{2+}]_o$, substituting Sr^{2+} for $[Ca^{2+}]_o$, or adding Mn^{2+} markedly affected the waveform of the LED. Lowering $[Ca^{2+}]_o$ increased the response amplitude. The results indicate that the LED arises from two separate Na^+ conductance increases as well as an increase in K^+ conductance. These conductance changes may be modified by divalent cations.

⁴This work was supported by National Institutes of Health grant EY-01531, Howard L. Gillary, P.I.

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The Evolution of Cytosolic Dipeptidases and Tripeptidases of Fishes⁶

LLOYD FRICK⁷

Six major cytosolic peptide hydrolases of general occurrence in higher bony fishes were resolved by starch gel electrophoresis. Five of these had overlapping, although distinct, substrate specificities against the di-

and tripeptides used as substrates and therefore may be considered bona fide isozymes. The other enzyme is a prolidase specific for carboxy terminal proline-containing dipeptides. Antibodies against two of the peptidases (PEP-C and PEP-S) were raised in rabbits and used in conjunction with substrate specificities to identify homologous isozymes in primitive fishes. The general substrate specificities of the isozymes re-

⁶This work was supported in part by a fellowship from the Jesse Smith Noyes Foundation.

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mained characteristic, although some minor changes were noted. An evolutionary trend in PEP-C tissue-specific expression was observed. PEP-C was widely distributed in the tissues of holosteans and primitive teleostean fishes, but was restricted to the eye and brain of advanced teleosts. A similar phenomenon has been reported for the C locus of lactate dehydrogenase (LDH) and for the B locus of

creatine kinase (CK). The tissue expression of the other peptidase isozymes showed no clear trends. The fact that the evolution of PEP-C tissue specificity resembles that of LDH-C and CK-B indicates that the strong evolutionary forces acting to restrict the expression of genetic loci to eye and brain are present in disparate areas of the metabolism of these organs.

Larval Behavior and Geographical Range of *Trochus niloticus* Linnaeus (Gastropoda: Prosobranchia)⁸

GERALD A. HESLINGA⁹

This paper considers ecological implications of development and larval behavior in a broadcast spawning archaeogastropod, *Trochus niloticus*. Larvae were reared through metamorphosis in the laboratory at Palau, Caroline Islands. Swimming trochophores hatched at 12-hr postfertilization (27–30°C). Larval shell formation was complete at 20 hr. Veligers had a small, unlobed velum that underwent resorption beginning on day 3. In controlled experiments, settlement and metamorphosis were induced by live coralline red algae (*Porolithon* sp.) and by a nonspecific algal film. In the presence of these substrates, settlement began at 50–60 hr and metamorphosis (defined here as loss of the velar cilia) was completed as early as

day 3 and as late as day 8. In the absence of live algal inducers, the duration of the planktonic phase was more variable; settlement occurred on days 3–10 and metamorphosis occurred on days 4–21. Larvae reared in the presence of phytoplankton showed no evidence of ingestion prior to metamorphosis.

Unlike the free-swimming veligers of tropical mesogastropods and neogastropods, *Trochus niloticus* larvae are characterized by lecithotrophy, rapid development, and limited ability to prolong the planktonic phase in the absence of a suitable settling substrate. The poor dispersal potential of this species corroborates and may explain its restricted native range in the Indo-West Pacific. It is suggested (1) that broadcast spawning archaeogastropods are phylogenetically constrained to lecithotrophy and short larval life-spans, and (2) that high ambient temperatures act to accelerate development and restrict larval dispersal in tropical representatives of this group.

⁸ This work was supported by the East-West Center, the Hawaiian Malacological Society, the Sigma Xi Research Society, and the Marine Resources Division, U.S. Trust Territory of the Pacific Islands.

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Nudibranch Distribution and Abundance on a Subtidal Reef at Yokohama Bay, Oahu

SCOTT JOHNSON¹⁰

More than 2 years of sampling nudibranchs on a subtidal reef have shown that 2 out of a total of 47 species comprise 83 percent of the individuals observed, although there is considerable diurnal/nocturnal variation in abundance. The distributions of the two dominant species are strongly correlated with their respective prey species of sponge: *Chromodoris youngbleuthi* with *Dysidea* sp. and an as yet unidentified chromodorid with *Luffariella* sp. Nudibranch distributions and degree of water agitation throughout the site also appear to be correlated, but this may reflect

the requirements of the prey sponges for moving water. Large and small individuals of both species and their eggs are present year round, suggesting that the populations are permanent and that no migration occurs. Abundance varies, but tends to be greatest during late spring and summer. Factors controlling abundance are still unknown, but there is no evidence of competition for food or space, or of predation upon adult nudibranchs. However, given the large potential recruitment considering the number of eggs produced, some factor must be limiting the population of at least *C. youngbleuthi*. Possibilities under investigation include mortality due to severe winter surf that strikes this coastline and predation upon larvae, with the latter considered more likely.

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Aspects of Symbiosis between the Dinoflagellate *Symbiodinium microadriaticum* Freudenthal and Three Species of Nudibranchiate Gastropods¹¹

STEPHEN C. KEMPF¹²

The nudibranchs *Pteraeolidea ianthina*, *Melibe pilosa*, and an undescribed species of *Melibe* maintain a symbiotic relationship with the alga *Symbiodinium microadriaticum* (more commonly called zooxanthella). Larvae produced by these nudibranch species are aposymbiotic, and the adults feed on animals that do not contain zooxanthellae. Reinfection of each generation must be accomplished by free-living algae or symbiotic organisms that are ingested along with

the normal adult foods. The algae are intracellular and the symbiosis is mutualistic. Experiments with ¹⁴C-labeled sodium carbonate show translocation of photosynthetically fixed carbon from symbiont to host in *Pteraeolidea* and *Melibe* sp. Longer survival of starved *M. pilosa* in constant light than in constant dark indicates that a similar translocation system exists in this animal. The presence of many lipid droplets associated with the zooxanthellae of *Pteraeolidea* and a few lipid droplets associated with the zooxanthellae of *Melibe* sp. suggests that lipid translocation from the algal cells to the host tissues occurs in these animals. Lipid translocation appears to be lacking in *M. pilosa*. *Pteraeolidea* and *Melibe* sp. apparently

¹¹This research was supported in part by a grant from the Hawaiian Malacological Society.

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derive additional nutrition from the digestion of algal cells while *M. pilosa* does not. Algal-derived nutrients result in extended survival of *Pteraeolidea* during starvation, with animals in constant light surviving up to 163 days and animals in constant dark up

to 81 days. The evidence presented is consistent with the hypothesis that the degree of benefit derived from the algal symbiont differs in the three nudibranchs, with *Pteraeolidea* obtaining the greatest benefit and *M. pilosa* the least.

Survivorship in Larvae of the Opisthobranch Gastropod *Aplysia Juliana*¹³

STEPHEN C. KEMPF¹⁴

Growth and metamorphic competence during long-term culture are being studied in the planktotrophic veliger larvae of *Aplysia juliana*. *Aplysia* larvae reared in laboratory cultures at $25.2 \pm 0.9^\circ\text{C}$ and fed the phytoplankton *Monochrysis lutheri*, attain a shell growth plateau 18 days after hatching. A tissue growth plateau is reached during the following 12 days of culture. Larvae are typically competent to metamorphose 30–35 days after hatching if exposed to a species of the alga *Ulva*. If larvae are not exposed to *Ulva*, they remain in the larval state and

continue feeding on *Monochrysis*; shell and tissue components have remained at their plateau masses for 144 days to date. No further morphological changes are apparent once the growth plateau is reached. Spontaneous metamorphosis has not been observed. Larvae from a culture that was tested for potential longevity, but was not sampled for weighing, were competent to metamorphose when tested 175 days after hatching. This culture was terminated after 295 days. The remaining two larvae appeared healthy, but were not tested for metamorphic competence. Mortality in long-term cultures appears to be due to inadequate culture conditions rather than larval senescence. The ability of these larvae to survive for long periods of time and maintain metamorphic competence greatly increases their potential for dispersal.

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Biogeographical Variation in *Macrobrachium rosenbergii* (Decapoda: Paleomonidae)¹⁵

MARY ELLEN LINDENFELSER¹⁶

Eleven populations of *Macrobrachium rosenbergii* were sampled at sites in southeast

Asia for morphometric data. Allozymic data were collected from nine of these populations. Discriminant function analysis on the morphometric data identified eastern and western groups within the species. Within each group proportionate carapace development is related to climatic aridity. Analysis of allozymic data suggests the same

¹⁵This research was funded by the East-West Center, International Communication Agency, and the University of Hawaii Prawn Aquaculture Program.

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division within the species as suggested by morphometric data. The degree of biochemical variation within and between subspecific groups is related to (1) theorized paleogeographic and paleoclimatic effects of the ice ages and (2) the effects of paleotectonic plate movements on gene flow. The effects of these

factors on the distribution of the species is also discussed. It is suggested that these paleotectonic plate movements are responsible for the formation of the zoogeographic discontinuity in southeast Asia known as Wallace's Line.

Does Colony Size Influence Breeding Synchrony and Reproductive Success?

CRAIG D. MACDONALD¹⁷

A six-year experimental field study of a colony of the damselfish *Plectroglyphidodon johnstonianus* was conducted to test the general validity of the Darling effect as originally conceived from studies of birds. This theory has not been tested in fishes or other lower vertebrates. The Darling effect postulates that social stimulation increases with colony size and affects the reproductive cycle of gregarious nesting birds with the result that synchronization of the breeding season increases. This is advantageous in that a shorter spread of breeding in a larger colony reduces the time available for predators to take eggs and young than in a smaller colony. Consequently, the reproductive success of individuals in a larger colony should be greater than in a smaller colony.

This study was conducted on a patch reef in Kaneohe Bay, Oahu, from May 1974 through February 1980. The experiment consisted of monitoring the breeding activities of a total of 64 nesting males for 19 months.

All nesting males were then removed. The breeding activities of a total of 29 nesting males that replaced them on the same reef slope were then monitored over a second 19-month period. Breeding synchrony and reproductive success were measured by recording the number and stage of all clutches of eggs in each nest.

Breeding synchrony did not differ between years within either of the experimental periods. Manipulation of the number of nesting males demonstrated that colony size did not influence breeding synchrony. The relative reproductive success of individual nesting males was greater at the reduced densities, evidently because of the increase of female to male ratios resulting from the removal of males. These results are the opposite of what the theory predicts. This study demonstrates that colony size does not influence breeding synchrony or reproductive success in colonies of *Plectroglyphidodon johnstonianus* as envisioned by Darling for birds. An explanation of why the Darling effect might have evolved in colonial nesting birds and not in fishes that also brood eggs on the substratum is presented.

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Measurements of Amine Efflux from Crustacean Sinus Gland

ROBERT NEWCOMB¹⁸

The crustacean sinus gland is currently the only preparation in which the electrical activity of neurosecretory terminals has been monitored with intracellular electrodes. As such, it is a useful system to study the electrical properties of neurosecretory terminals. Quantitation by bioassay of hormone release is also possible in this system. The sinus gland is therefore the only system in which intracellular recordings from nerve terminals can be matched with release of a biologically active peptide. In order to supplement the data on hormone release and as a preliminary step in developing chemical methods for quantitating peptide release in this system, the efflux of primary amine compounds from sinus gland has been monitored under various perfusion conditions.

The standard fluorescamine assay for primary amines was modified to allow for

the detection of <10 pmol peptide amine terminus in saline solutions, and a perfusion system was designed to obtain maximum sensitivity: a small fraction size (23 μ l), a small bath volume (30 μ l), and a quick solution changeover time (>80 percent complete after 5 fractions). Using the fluorescamine assay to monitor amine content in these fractions, the efflux of amines from a sinus gland in normal saline, high K^+ saline, low Ca^{2+} -high Mg^{2+} saline, and H_2O has been investigated. No measurable efflux of amines (<10 pmol/38 sec) has been observed in normal and high K^+ salines, while a measurable level may occur in low Ca^{2+} salines. Chemical characterization of high K^+ perfusates and low Ca^{2+} perfusates is being attempted by base hydrolysis and column chromatography, respectively. In addition, a new method for labeling peptides with 3H methyl iodide is being developed with the hope of monitoring and perhaps characterizing the peptides present in high K^+ perfusates of sinus glands.

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Does Ejaculation in the Hamster Result from the Self-Induced Release of β -Endorphin?¹⁹

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Endorphins, newly discovered endogenous peptide neurotransmitters, produce pharmacological effects similar to other opiate-

receptor binding substances, such as morphine or heroin. Research on endorphins has linked their role to the modulation of pain and pleasure. Recent studies have shown that injection of low doses of β -endorphin into the aqueducts of the brain can cause central brain seizures of hyperactivity that may correspond to the "rush" of intense pleasure compared by some addicts to the experience of orgasm. It has been reported by others that at ejaculation endorphin appears in the bloodstream of hamsters.

The purpose of our research is to inquire

¹⁹ This work was supported by the National Institutes of Arthritis, Metabolism, and Digestive Diseases, grant number 2 S06 RR08125-06, administered via the Minority Biomedical Program of the National Institutes of Health.

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whether ejaculation in the hamster might also be associated with central brain seizures and result from self-induced release of endorphins. To do this we utilized the ^{14}C -2-deoxyglucose autoradiography method (Sokoloff et al. 1977. *J. Neurochem.* 28:897–916) which maps the local neural activity of the brain by measuring its regional glucose consumption. This method was applied to

male hamsters maintained in a sexually active or inactive state for approximately 30 min. A comparison of the resulting brain activity maps did not reveal any brain areas to be significantly stimulated or inhibited by sexual activity. Whether this result was due to methodological insensitivity or to the spinal nature of sexual activity remains to be determined.

Utilization of the ^{14}C -Deoxyglucose Method to Map Brain Activities Present in Wild Rats during Fear²³

KEVIN PANG,²⁴ EUGENE LEE,²⁵ ROBERT BLANCHARD,²⁵ and BRUCE MORTON²⁴

Fear is the normal response to life-threatening stimuli. It allows the organism to respond rapidly and forcefully in the face of danger. Although it is ancient and universal, the molecular and physiological basis of fear is only poorly understood, as is its influence as a motivational factor in complex behavior. In the present study, the neuronal activities of the entire brain of very frightened and of calm wild rats were mapped at high resolution using the Sokoloff ^{14}C -deoxyglucose autoradiographic technique (^{14}C -DG) (Sokoloff et al. 1977. *J. Neurochem.* 28:897–916). The activities of various brain structures and areas in fearful rats and calm control rats could then be compared.

Without their awareness, the wild rats were injected with 10 $\mu\text{Ci}/100\text{ g}$ ^{14}C -DG

through a jugular vein cannula. The control rats were put back into their cages and left undisturbed. In the experimental rats, the fear reaction was stimulated by noisy human approach and painless assault. The experimental and control animals were maintained in these contrasting environments for 45 min. During this period, ^{14}C -DG along with glucose was consumed in proportion to brain energy needs. As a result, metabolically inert ^{14}C -DG-6-phosphate was deposited over the regional areas of the brain in proportion to their ongoing functional activity. The animals were killed and their brains were perfused and fixed. The brains were then removed, frozen, and 20 μm coronal frozen sections were sliced and placed against X-ray film for autoradiography. The autoradiographs of frightened and calm rats were then compared. Several areas of elevated brain activity were found to be present in the frightened rats. These included the central gray, an area known for its involvement in fear mediation, hypothalamic nuclei, brainstem, and cerebellar areas. The inferior colliculus was inhibited compared to the control animals.

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The Partitioning of Reproductive Energy between Ova and Protective Capsules in Marine Gastropods of the Genus *Conus*²⁶

FRANK E. PERRON²⁷

The physical strength and energetic cost of egg capsules belonging to ten species of Hawaiian *Conus* were determined in the laboratory. Capsular material was found to contain 5447 ± 109 cal/g as opposed to 6236 ± 55 cal/g for ova. Capsules accounted for up to 50 percent of total reproductive energy devoted to capsules and ova. Both

the puncture resistance of capsules and the proportional energy allocation to capsules increased with increasing egg size between species. Since egg size was found to be positively correlated with the length of the pre-hatching developmental period, strong capsules produced by species with large ova may have evolved as a result of selection for improved protection of embryos from predation and physical stress during a protracted period of development. The allocation of reproductive energy to capsules as a function of egg size reflects the cost of producing stronger capsules.

²⁶ This research was supported in part by grants from the Hawaiian Malacological Society and the Sigma Xi Research Society.

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A Multispecies Production Analysis of Hawaii's Offshore Handline Fishery²⁸

STEPHEN RALSTON²⁹

Examination of the Hawaii Division of Fish and Game catch report data set (1959–1978) revealed that 14 species of bottomfish are commonly taken in the deep-sea handline fishery around the main Hawaiian Islands. Cluster analyses showed these species separated into three basic recurrent groups which appear to segregate by depth.

Applications of the Graham–Schaefer surplus production model to the data, classified by fishing bank and species group, were partially successful in describing the dynamics of the fishery. In particular, the analyses for the Maui–Lanai–Kahoolawe–Molokai bank, and in addition the deepest species group, yielded statistically significant results that accounted for over half of the total landings in the fishery. Based upon comparisons of production between banks, annual sustainable yields of up to 300 kg of bottomfish per nautical mile of 100-fathom isobath appear possible. Differences in the growth curves of the three species groups provide interesting insights into the fishery.

²⁸ This research was supported by Sea Grant, University of Hawaii; Sea Grant, University of Washington; National Marine Fisheries Service, Honolulu Laboratory.

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A Comparison of Two Visual Survey Techniques for Fish Populations³⁰

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Two visual census techniques for describing and quantifying fish communities, the Brock method and the Jones and Thompson method, were compared in terms of replicability, observer bias, minimal number of replicate surveys required to represent adequately the species composition of a specific fish community under study, daily variations in the data, and sensitivity to distinctions between fish communities. In addition, the degree of correlation between surveys of the two methods was calculated. More than 250 surveys of each method were conducted at five sites off Molokai and at Hanauma Bay off Oahu.

Spearman rank correlation coefficients were calculated between single surveys of each method, and between the averages of four replicate surveys of each method. These analyses were performed on the abundance ranking of each species recorded by the two survey techniques. When four replicate surveys were averaged, an increase in the correlation within methods was reflected in an increase in the correlation between methods. This direct relationship suggested that replicate surveys by each method gave reliable estimates.

The correlation coefficients for Jones and Thompson surveys were significantly lower than those for Brock surveys, indicating that

the results of Jones and Thompson surveys were more variable. A significant difference between data collected by different Jones and Thompson observers suggested that observer bias was responsible in part for the lower replicability.

The mean number of species recorded per survey and the total number of species recorded per site were approximately equal for the two methods. Consequently, the minimal number of replicate surveys required to represent adequately the species composition of the community under study would be approximately equal for the two methods. There were no statistically significant daily variations in the data. The two methods were equally sensitive to distinctions between fish communities.

Both the Brock method and the Jones and Thompson method are valid visual survey techniques. When an area is under intensive study and replicable surveys are essential, the Brock method should be used. In cases where absolute abundances are required or where the length of each individual fish must be noted to obtain biomass approximations, the Brock method must be used. When available field time is minimal and the main objective is to characterize fish communities so that sites can be distinguished on that basis, the Jones and Thompson method is more cost-effective. The Jones and Thompson method would also be preferred when bottom time is a critically limiting factor or when conditions of strong current, heavy surge, or extreme vertical relief prohibit the setting of a transect line.

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Cryptofauna of French Frigate Shoals, Northwest Hawaiian Islands³²

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Coralline materials sampled at French Frigate Shoals, were collected from different habitats and analyzed for cryptofauna. Substrata include live coral; dead branching coral; branching coral colonies with approximately 50 percent living tissue; and dead, eroded, coral rock. The carbonate fraction of the coral was removed by nitric acid dissolution, and the organisms were then identified and counted.

Polychaetes comprised the dominant taxon, with the families Syllidae, Eunicidae, Terebellidae, Sabellidae, Spionidae, and Nereidae represented in all samples of substrata, except the live coral. The endolithic fauna from the live coral was extremely sparse, confirming reports from other studies. Both numerical and species abundance were highest in the eroded coral rock,

which contained 18 polychaete species and approximately 16 species of crustaceans. Mollusks were represented primarily by vermetids. Species diversity (H') values for polychaetes are 1.759 for dead, eroded coral; 1.536 for the dead, branching coral; and 1.095 for the partially living branching coral. There were no polychaetes in the living coral sample.

The polychaete assemblages in these carbonate substrata are similar in familial composition to those found in other Indo-Pacific coral reefs, e.g., Marshall Islands, Guam, and the Great Barrier Reef. The French Frigate Shoals community appears to differ only in species composition. The families represented exhibit diverse feeding methods, including filter-feeders, selective detritivores, herbivores, and carnivores. Worms may erode burrows; utilize existing crevices in the dead, eroded rock; or live among encrusting and filamentous algae. This variety of habitats and feeding types allows a diverse assemblage of polychaetes to occupy dead coral rock.

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Ontogeny of Lactate Dehydrogenase in Developing Carp Embryos

CLYDE S. TAMARU³⁴

The enzyme lactate dehydrogenase, (LDH) E.C. 1.1.1.27, in the common carp *Cyprinus carpio* L. exhibits an extremely rich isozyme system. Restricted tissue specificities of isozymes, immunoprecipitation followed by starch-gel electrophoresis, and electrophoretic detection of a variant allele for LDH, all support the hypothesis that the LDH isozymes in the common carp are

encoded by five structural gene loci, e.g., A, B¹, B², C¹, and C². In the adult tissues, the A form is predominantly expressed in white skeletal muscle, the B¹ and B² are found in a variety of tissues, and the C¹ and C² are almost completely restricted to liver.

The restricted tissue distribution of the C¹ and C² in the adult provides an ideal system for testing the assumption of whether tissue-specific isozymes can be used as gene markers for the differentiation of their respective tissues during development.

Spectrophotometric analysis of embryo

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extracts shows a decrease in LDH activity from fertilization until hatching. This is then followed by an abrupt increase in LDH activity at hatching, which continues through later development. Electrophoretic analysis of the same embryo extracts reveals the presence of isozymes composed of A, B¹, and B² subunits at fertilization. The abrupt

increase in activity at hatching is apparently due to the synthesis of both types of C subunits.

Histological examination of embryos fixed at the same time intervals as the embryo extracts demonstrate that the appearance of C subunits and the time of liver differentiation are closely associated.

Mode of Action of Palytoxin, a Hawaiian Spear Poison of Marine Origin

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Palytoxin is a marine poison, extracted from a zoanthid of the genus *Palythoa*. In Maui, the Hawaiian people knew the organism producing palytoxin as *limu make O Hana*, or "a deadly seaweed of Hana." They used it as a spear poison and even today tell legends of its origin from the death of a shark god.

Excluding peptide toxins, palytoxin is the most potent toxic substance known. Its toxicity exceeds that of tetrodotoxin or ciguatoxin at least by an order of magnitude. The lethal effects of palytoxin have been produced in many experimental animals. In all cases, palytoxin somehow seemed to interfere with the mechanical activity of these animals; the ultimate cause of their deaths was suffocation due to heart failure. In cardiac muscle, palytoxin caused ventricle

contracture. The induced contracture was associated with increased calcium influx. Palytoxin at extremely low concentrations also inactivated sperm motility. Its effects resemble those produced by high concentrations of a known calcium ionophore, A₂₃₁₈₇. Elevated extracellular calcium levels increased the motility inhibition produced by both A₂₃₁₈₇ and palytoxin. The effects of both of these agents were reversed by caffeine, an inhibitor of the phosphodiesterases, enzymes responsible for C-AMP degradation. Palytoxin was also found to increase the ⁴⁵Ca influx of hamster sperm.

These results suggest that many, and perhaps all, of the toxicity effects of palytoxin may result from its interference with calcium metabolism by exposing the cell to uncontrolled calcium entry. Since calcium is involved in the control of numerous cellular phenomena, the final solution of the mechanism of action of palytoxin will be significant in several ways, including the introduction of palytoxin as a defined tool for the clarification of cellular calcium metabolism.

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Smaragdia (Gastropoda: Neritidae), a Seagrass Animal

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In Hawaii, the snail *Smaragdia bryanae* grazes the seagrass *Halophila hawaiiiana* and is limited in its distribution to that plant. They are found together around the islands of Kauai, Oahu, Molokai, and Maui. This grazing interaction is unusual because most invertebrates associated with seagrasses or other aquatic macrophytes feed on epibiota of the leaf surface rather than higher plant tissue. The utilization of such tissue by gastropods requires specialization of the digestive system and radula. The radula of *Smaragdia* has been described as unique among the Neritidae, having modifications approximating the type found in higher snails, where a diet of macrophytes is usual for herbivorous species.

Feeding behavior of the snail has been observed in field and aquarium. Patterns of leaf damage were recorded photographically at various magnifications. A consistent and characteristic damage pattern can be recognized.

The *Smaragdia*-seagrass association in Hawaii seems to be part of a widespread

phenomenon. *Smaragdia* on seagrasses have been reported in southern Japan, the Seychelle Islands, the Mediterranean, and the Caribbean. Recent and fossil (Tertiary) *Smaragdia* records indicate that the range of the genus is pantropical plus Mediterranean, distribution limits probably being set by temperature. Seagrasses are found at all sites where the snail is reported, but an exclusive relationship with *Halophila* is ruled out by the presence of the snail in the Mediterranean, where that plant is but a recent migrant since the opening of the Suez Canal. From past records, the snail seems to be found most frequently where large numbers of seagrass species co-occur.

The ecological nature of this plant-animal association in other areas is not yet known, but extremely similar patterns of leaf damage have been seen on herbarium specimens of *Halophila* from the Philippines, the Caroline Islands, Australia, and Madagascar. Marks that could be *Smaragdia* grazing damage were also seen on specimens of *Thalassia* and *Halodule* from the Philippines. It is suggested that *Smaragdia* may be, like the dugong, a true "seagrass animal," ecologically dependent upon the marine angiosperms.

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The Roles of Ions and Osmotic Pressure in Glycine Uptake by *Nereis succinea*

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Uptake of 1 μM ^{14}C -glycine by the euryhaline polychaete *Nereis succinea* was a sigmoidal function of environmental salinity. The exponential portion of the curve occurred between 10 and 35 percent SW, while

maximal uptake ($87.0 \text{ nmol g}^{-1} \text{ hr}^{-1}$) was found above 35 percent SW. These respective types of uptake activity correspond to the osmoregulating and osmoconforming ranges of this animal. The influence of size on uptake also varied with external salinity. Slopes of double log plots of wet weight versus uptake for salinities at which the

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animal osmoconforms range from 0.67 to 0.80, suggesting that uptake is a surface-related process. At 25 percent, an osmoregulating salinity, this slope is 1.10, indicating a direct relationship between wet weight and influx. Three salines were prepared to study the effects of $[\text{Na}^+]$ and osmotic pressure alone on glycine uptake. Sodium-free SW was prepared, substituting Li^+ for Na^+ . ^{14}C -glycine uptake rate in a series of dilutions of this saline was a hyperbolic function of ion concentration, saturating at $18.6 \text{ nmol g}^{-1} \text{ hr}^{-1}$. Variable Na SW consisted of media having differential $[\text{Na}^+/\text{Li}^+]$, all other ions and osmotic pressure being equi-

valent to SW. For $[\text{Na}^+]$ equivalent to 0–10 percent SW, ^{14}C -glycine uptake rate increased rapidly with $[\text{Na}^+]$. Above 10 percent SW, a slow rise in entry rate was observed. Variable osmotic pressure SW was made with ion concentrations equal to that of 10 percent SW and osmotic pressure raised with mannitol. The relationship between osmotic pressure and influx was sigmoidal, closely corresponding to the effect of salinity. These results suggest that the transport of glycine in this animal is by a sodium-dependent system regulated by the osmolality of the medium.

The Relationship between the Annual Cycles of Gametogenesis and Gonad Size in the New Zealand Sea Urchin, *Evechinus chloroticus* (Valenciennes)

MICHAEL WALKER³⁸

Annual cycles of gametogenesis and gonad size were studied in three populations of the urchin *Evechinus chloroticus* inhabiting shallow subtidal reefs in the Auckland Harbour. Twenty urchins were taken from each population at intervals of 2 months. Test size and gonad volume were measured for all these urchins, and samples of their gonads were embedded in paraffin for histological analysis of the gametogenic cycle.

Gametogenesis leading to spawning begins in the early spring (September), with spawning occurring in midsummer (December–January) and male urchins developing mature gametes before females. Mature ova are about $100 \mu\text{m}$ in diameter. Nutritive

phagocytic tissue is most prominent in the gonads from late autumn to spring (April–September). During gametogenesis the nutritive phagocytic tissues become less prominent in histological sections of the gonads in both sexes, but quickly occupy much of the cross-sectional area of the gonads following spawning. Gonad volumes of urchins increase gradually from late autumn to spring, increase rapidly between late spring and early summer, and decrease some time after spawning. The rapid increase in gonad volume during spring coincides with gametogenesis, while the gradual increase in gonad volume during the winter months may be due to the gradual accumulation of nutrients by the nutritive phagocytes. The period of greatest gonad growth also coincides with declining test growth rates, indicating that test and gonad growth alternate in this urchin.

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Responses of a Hawaiian Reef Fish Community to a Catastrophic Storm

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On 8 and 9 January 1980, a severe cyclonic storm struck the west (Kona) coast of the island of Hawaii. Wind-generated waves in excess of 8 m battered the normally protected leeward fringing reefs and caused widespread reef destruction and shoreline alteration. Extensive nearshore shallows (1–3 m) were denuded of almost all bottom cover and marine life. Corals, sand, and debris from this area were thrown up on the shore or were swept seaward over the edge of a 5-m drop-off approximately 75 m offshore. Such material was deposited at the base of this drop-off, forming a layer of rubble up to 1.5 m thick that buried previously deposited rubble and live *Porites lobata* corals. Other storm-associated damage to the massive corals below this drop-off was minor. Beds of the fragile finger coral, *Porites compressa*, which lay seaward of this zone, sustained substantial damage, however. In 9 m of water, up to 60 percent of the coral cover was smashed, and in 13 m, over 25 percent was damaged. Broken and dislodged heads could be observed down to a depth of 27 m.

Fish mortality directly attributable to the storm was remarkably slight. The small numbers of fishes that were killed tended to be either surge zone species or individuals normally residing in tidepools. Large numbers of individuals left the shallows during the storm for deeper water around and below the 5-m drop-off. Transects in these areas showed the influence of these refugees in terms of increased numbers of juveniles, adults, and species present. Population in-

creases were still evident after almost 3 months.

A major faunal shift resulting from the storm was the tenfold increase in the numbers of the territorial damselfish *Stegastes fasciolatus* in the areas below the drop-off. Within 2 weeks after the storm, barren rock and calcareous rubble developed a heavy growth of bright-green filamentous algae, particularly of the genus *Enteromorpha*. This algae was heavily grazed by herbivores and by 1 month after the storm had disappeared except in the extreme shallows and within some of the damsels' territories. This abundance of early colonizing algae enabled this highly site-oriented species to shift successfully to a new habitat area. Recolonization of the shallows is presently underway, primarily by small species and juveniles.

In the deeper water finger coral areas, diurnal fish populations remained unchanged or increased slightly, even in light of substantial coral destruction. Algal growth on dead coral rubble opened up new feeding areas to wandering herbivores. During daylight and twilight periods there was an increase in disordered movement about the reef due primarily to disruption of path habits and changes in topography. An unusually high number of predatory events was observed shortly after the storm. Night transects did not show significant reductions in nocturnally active or diurnally inactive individuals. *Porites lobata* areas of high relief and large numbers of diurnal shelterers remained mostly intact. Heavily damaged finger coral areas had few inactive adult shelterers, but damage was patchily distributed and total area of suitable shelter was still high.

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Habitats of Spionid Polychaetes of Oahu, Hawaii, and Johnston Atoll⁴⁰

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Spionid polychaetes from seven different habitat types around the shores of Oahu, Hawaii, and Johnston Atoll were collected from carbonate rock, sand, fine sediments, and oysters. Samples were processed by dissolving away the carbonate material in a nitric acid and formalin solution and extracting the polychaetes. A total of 5335 spionids belonging to 14 genera and 22 species were recorded. Three are endemic, five have an Indo-West Pacific distribution, and seven are cosmopolitan. Spionids constitute up to 75 percent of the total number of polychaetes at Johnston Atoll and 50 percent on Hawaiian reefs. Since they are

small worms, they form a smaller percentage of the polychaete biomass.

Spionids with a variety of adaptations were represented. *Malacoceros* cf. *vanderhorsti* and *Streblospio benedicti* tolerate reduced salinities and are characteristic of fine sedimentary habitats in estuarine canals and streams. *Pygospio* sp. 1 tolerates shifting sand, while *Prionospio* spp. are common in lagoonal sediments from Kaneohe Bay. *Polydora websteri* reaches densities of 405/m² in coralline substrata in Kaneohe Bay and is of economic importance because of its ability to bore into the shells of commercially valuable oysters, often rendering them unmarketable. Habitats such as reef limestone from Johnston Atoll and Hawaii and coarse sediment with coral rubble are characterized by boring species, while lagoonal sediments and shifting sand are characterized by burrowing species.

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Yolk Utilization in Teleost Development

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There are six genetic loci coding for isozymes capable of hydrolyzing peptides to free amino acids in the Japanese medaka (*Oryzias latipes*). Each of these peptidase (PEP) isozymes has a distinct substrate specificity and adult tissue distribution. By separating embryonic tissue from yolk in developing embryos, the distribution of PEP isozymes in the two compartments has been compared. Two isozymes—PEP-C and PEP-S—are predominantly localized in the yolk during development, while PEP-B is only present in the embryonic tissue. PEP-C is largely restricted to brain in the adult. It is

present in the yolk from oogenesis throughout development with a relatively constant amount of activity until late organogenesis. PEP-S is found in yolk in small amounts during early stages and undergoes a dramatic increase in specific activity in yolk at the time of vitelline vein differentiation. This is the stage when yolk begins to be utilized at high rates and embryonic metabolism increases (Monroy et al. 1961). This concurrence of PEP-S yolk activity increase with yolk utilization suggests that this isozyme has a specialized role during development. PEP-S may mobilize yolk peptides to their free amino acids, which are then available to the growing embryo to be used for protein synthesis and/or metabolic energy production.

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